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Report of the Secretary-General

Addendum

Biotechnology for sustainable agriculture*

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I. Introduction

1. Biotechnology is defined in article 2 of the Convention on Biological Diversity as any technological application that uses biological systems, living organisms or derivatives thereof to make or modify products or processes for specific uses. Agricultural biotechnology is a collection of scientific techniques, including genetic engineering, that are used to modify and improve plants, animals and micro-organisms for human benefit. It is not a substitute for conventional plant and animal breeding but can be a powerful complement. The present report explores what roles biotechnology may play in contributing to sustainable agriculture and rural development, with particular concerns for biosafety and biodiversity. It focuses on several major policy issues, presenting biological diversity as a source of raw product for crop and animal improvement, including the use of biotechnology. And it considers biosafety as a major domain for addressing the impact of biotechnologies on health and the environment. The report suggests policy issues that will need to be resolved by Governments if biotechnology is to contribute effectively to the food and livelihood security of developing countries in the next millennium.

2. The potential contribution of modern biotechnology to the achievement of global food security remains uncertain. While the application of agricultural biotechnology techniques can increase food security, most current agricultural biotechnology research lacks pro-poor objectives that could positively impact on sustainable agriculture and rural development objectives. The moral imperative for making modern agricultural biotechnologies, such as genetically modified (transgenic) crops, readily and economically available to developing countries who want them is compelling. There are a few research programmes that include biotechnologies that are designed to help developing countries to achieve food security, but additional resources are needed not only for the research efforts but also for effective mechanisms to ensure their safe utilization.

II. Agricultural biodiversity

3. Agricultural biodiversity encompasses the variety and variability of animals (including aquatic animals), plants, forestry and micro-organisms — at the genetic, species and ecosystem levels — necessary to sustain the key functions of the agro-ecosystem and its structure, as well as processes for and in support of agricultural production and food security. The biological resources contained within agricultural biodiversity are of direct and vital importance to the food security and socio-economic development of all countries.

4. The Conference of the Parties to the Convention on Biological Diversity, in its decision III/11, recognized the special nature of agricultural biodiversity, its distinctive features, and problems needing distinctive solutions. Indeed, many of the necessary institutional arrangements for promoting the conservation and sustainable use of crop, forest, farm animal and fish genetic resources are in place or under development, mainly within the Food and Agriculture Organization of the United Nations (FAO). These include:

- International legal agreements, such as the international undertaking on plant genetic resources;
- The intergovernmental Commission on Genetic Resources for Food and Agriculture;
- Global assessments and information systems, such as the domestic animal diversity information system;
- Internationally agreed plans of action, such as the global plan of action for the conservation and sustainable utilization of plant genetic resources for food and agriculture.

5. Agricultural biodiversity provides many ecological services within agro-ecosystems such as nutrient cycling, pest and disease regulation and pollination; these are outlined in an addendum to the report of the Secretary-General on integrated planning and management of land resources (E/CN.17/2000/6/Add.4). An understanding of the functions of biodiversity in agricultural systems will assist efforts to optimize the benefits from and minimize the risks of agricultural biotechnology.

6. FAO and the Conference of Parties to the Convention have continually promoted the development of national plans and strategies for the conservation and sustainable use of agricultural biodiversity. Because modern agricultural biotechnologies offer ways to improve and expand the sustainable use of genetic resources, they should be considered in any national planning regarding the sustainable use of agricultural biological resources in order to meet sustainable agriculture and rural development objectives.

III. Potential of biotechnology for sustainable agriculture and rural development

7. Agricultural biotechnologies have major potential for facilitating and promoting sustainable agriculture and rural development. They could also generate environmental benefits, especially where renewable genetic inputs can be effectively used to substitute for dependency on externally provided agrochemical inputs. The fact that genes or genotypes (e.g., varieties, breeds) can constitute locally renewable resources is of profound significance to the further development of sustainable agriculture and rural development. However, the power of modern biotechnologies to generate useful genotypes has not yet been harnessed for poorer farmers.

8. Nevertheless, the extent to which modern biotechnology will contribute to the achievement of food security for all is still an open question.[1] Science alone is unlikely to provide a complete solution to the problems of rural development. There are many processes, factors and socio-economic structures underlying poverty in rural areas, such as lack of access to land and other productive resources, low purchasing power, political powerlessness, fragile environments and distance from markets. Agricultural (or indeed plant biotechnology) research is but one factor which could impact on rural poverty; it is not a panacea for sustainable agriculture and rural development.

9. Comparative reviews of the state of agricultural biotechnologies in some developing countries have been carried out by the International Service for National Agricultural Research — Intermediary Biotechnology Service, a Consultative Group on International Agricultural Research (CGIAR) centre, and the Organisation for Economic Cooperation and Development (OECD), which concluded that the majority of developing countries have limited practical access to the tools and germplasm necessary to apply more sophisticated biotechnology research to their national needs. The barriers to such access are many and include lack of financial, scientific and infrastructural resources.

10. Biotechnology research has not been closely integrated with the problems and constraints confronting low-income farmers in the agricultural sector of developing countries. Biotechnology needs to be focused on some key problems within sustainable agriculture and rural development that historically have not been effectively addressed by conventional technologies.

11. Governments, scientists, non-governmental organizations, donors and CGIAR will have to consider the development of innovative mechanisms for the transfer of biotechnologies in developing country agriculture. Long-term public-sector funding will be necessary if the dissemination of agricultural biotechnology research is to benefit the poorer strata of society.

12. Over the longer term, there is little doubt that some biotechnological approaches to agricultural improvement could generate social, economic and environmental benefits if specifically targeted at the specific needs of poorer groups. While a vast range of approaches for the biotechnological improvement of such agronomic traits are either under study or in early development phases, given the current lack of focused public sector support for pro-poor agricultural biotechnology it is unlikely that poorer farmers will have economic access to such improvements in the short term.

13. Participation of poorer farmers and other stakeholder groups in developing sustainable agriculture and rural development is a key theme throughout Agenda 21. Greater impact of publicly funded biotechnologies on sustainable agriculture and rural development may result from including farmers' groups in decision-making regarding the definition of sustainable agriculture and rural development objectives that might be met by agricultural biotechnology. Communication channels and constructive dialogue between upstream public-sector

agricultural biotechnology researchers and downstream on-farm researchers and farmers' groups are poor. There are currently no mechanisms for effective translation of farmers' expressed needs into research action through appropriate "participatory problem transfer". Most public-sector bodies that either fund or conduct agricultural biotechnology research have no incentive mechanisms that would ensure that agricultural biotechnology research is targeted to the needs of poorer farmers or social groups. That is a public policy problem that can only be addressed by Governments and their institutions.

14. Agenda 21 proposes on-farm research in the development of non-chemical alternative pest management technologies. Biotechnology could contribute to the breeding of plant varieties or animal breeds tolerant to pests or pathogens that are currently controlled by agrochemicals, which could allow reductions in agrochemical use through the substitution effects of particular genes conferring tolerance.

15. Strategies for the sustainable use of genetic resources, such as resistance genes against pests or pathogens, are now emerging. The third CGIAR system review has proposed that CGIAR centres promote a global initiative for integrated gene management, which would, *inter alia*, promote more sustainable use of useful genetic resources.

16. A search through the scientific literature on biotechnology reveals a range of agricultural biotechnological research that could impact favourably on all of the priority areas of Agenda 21, chapter 14. However, the relevance of uncritically listing all biotechnology research which is under way and might meet sustainable agriculture and rural development objectives should be questioned. The development of a technology does not guarantee its widespread dissemination — especially to poorer social groups. When it comes to food security, it is the practical application of the research that matters, rather than the promise of the "pipeline" research orientation. The agricultural biotechnology research community lacks concrete examples of pro-poor applications of molecular-level biotechnology being put to use in farmers' fields on a scale necessary to have an impact on rural poverty.

17. Over the longer term, there is much promising agricultural biotechnological research that in theory might be harnessed for sustainable agriculture and rural development objectives, such as increasing yields and sustainable utilization of plant genetic resources for food including:

- Apomixis, an asexual technology of plant reproduction that can provide economic incentives to replant harvested seeds;
- Micropropagation and plant tissue culture technology (e.g., to generate disease-free plantlets of vegetatively propagated staple crops, such as cassava, potato, sweet potato, taro, bananas and plantains);
- Improved fermentation technologies;
- Improved technologies for generating biomass-derived energy;
- Generation of higher nutrient levels (e.g., pro-vitamin A, iron, essential amino acids) in nutrient-deficient staple crops, such as rice;
- Marker-assisted-selection strategies for improving agronomic traits in animal and plant varieties/breeds, including yield potential;
- Development of genotypes with abiotic stress tolerance (e.g., aluminium and manganese tolerant crops which can grow in acidic soils, salt tolerance, drought tolerance);
- Vaccines against animal diseases;
- Insect resistance;
- Bacterial, viral and fungal disease resistance;
- Better crop digestibility for animals and humans;
- Delayed overripening of fruits and vegetables (e.g., to reduce post-harvest losses).

18. Very few public-sector institutions or organizations are involved in the transfer of appropriate biotechnologies to the crops and farming systems of rural groups in developing countries, reflecting the current bias in agricultural biotechnology research to commercial markets. Internationally, there are only a handful of underfunded agricultural biotechnology initiatives (public or private sector) with an explicit focus on poorer farmers as their primary clients/markets. Some examples are the Center for the Application of Molecular Biology to International Agriculture; the FAO-facilitated Technical Cooperation Network on Plant Biotechnology for Latin America; the International Centre for Tropical Agriculture

Cassava Biotechnology Network; and other biotechnology networks created and managed by the CGIAR international centres. Several national Governments of developing countries have good programmes on agricultural biotechnologies, such as Mexico, Argentina, Brazil, China, India and Egypt.

19. The Commission on Science and Technology for Development will address the topic "National capacity-building in biotechnology" in its current work programme. Particular attention will be given to agriculture and agro-industry, health and environment. The theme will include the transfer, commercialization and diffusion of technology, as well as bioethics, biosafety, biodiversity and regulatory matters affecting these issues to ensure equitable treatment. In its resolution 1999/61, the Economic and Social Council also recommended that the Commission initiate a dialogue that involves the private and the public sectors, non-governmental organizations and specialized biotechnology centres and networks to raise issues concerning global development in biotechnology (see also General Assembly resolution 54/201).

20. In 1991, the intergovernmental Commission on Genetic Resources for Food and Agriculture requested the preparation of a code of conduct on plant biotechnology, with the aim of maximizing the positive effects and minimizing the possible negative effects of biotechnology in agriculture. However, the Commission has suspended work on the draft, pending the completion of the negotiations for the revision of the international undertaking on plant genetic resources. At its eighth session, in April 1999, the Commission requested that a report on the status of the draft code of conduct be submitted at its ninth session, in 2001.

IV. Assessing impacts of biotechnology on health and the environment

21. There are concerns about potential risks posed by some aspects of biotechnology. These risks fall into two basic categories: the effects on human and animal health, and the environmental consequences. Caution must be exercised in order to reduce the risk of transferring toxins from one life form to another, of creating new toxins or of transferring allergenic compounds from one species to another, that could result in unexpected allergic reactions. Risks to the environment include the possibility of out-crossing, leading, for example, to the development of more aggressive weeds or wild relatives with increased resistance to diseases or environmental stresses, upsetting ecosystem balance. There is also the potential loss of biodiversity, for example, resulting from the displacement of traditional cultivars by a small number of genetically modified cultivars, and the potential for increased crop vulnerability resulting from the possible widespread adoption of varieties with simple, monogeneic, disease resistance mechanisms. However, in principle, these latter effects are no different from those that may result from many conventional approaches to plant breeding.

22. Policy decisions taken in regard to biosafety regulations will have long-term implications for the sustainability of agriculture and food security. Many genetic engineering approaches to crop improvement arise from a lack of suitable conventional approaches to dealing with a particular agronomic problem or need. It appears that long-term negative implications for agriculture and food security can arise equally from having biosafety regulations that are either too lax or too stringent.

23. Genetic engineering approaches have considerably broadened the range of gene pools which are now accessible for crop improvement purposes. If countries expect to benefit from modern biotechnologies in their agriculture and food sectors, they will have to give serious consideration to the drafting of biosafety regulations that are tailored to meet their socio-economic needs. Biosafety regulations and standards for risk assessment need to be harmonized within eco-regions since environments are common across political boundaries.

24. The development of international norms in biosafety is essential. In 1995, the Conference of Parties to the Convention on Biological Diversity established a negotiation process to develop — in the field of the safe transfer, handling and use of living modified organisms — a protocol on biosafety, specifically focusing on the transboundary movement of genetically modified organisms resulting from modern biotechnology. After five years of negotiations, ministers and senior officials of over 130 Governments finalized a legally binding agreement for protecting the environment from risks posed by the transboundary transport of living modified organisms created by modern biotechnology, during formal negotiations to

adopt the protocol, held at Montreal, from 24 to 28 January 2000.[2] The issues of biosafety and biotechnology are also to be addressed by the Codex Alimentarius, the joint FAO/World Health Organization (WHO) Commission that determines global food standards. It has set up an ad hoc intergovernmental task force on foods derived from biotechnology that is scheduled to meet from 14 to 17 March 2000 in Tokyo.

25. Biosafety assessment requires that risks, benefits and needs be given a balanced assessment in relation to genetically modified organisms. Many opponents of plant biotechnology cite biosafety as the key risk-based issue for the more stringent regulation of transgenic organisms. Much controversy has been generated over the safety of transgenic foods.

26. It should be borne in mind that in a biological sense, the inter-species genetic modification of foods is not inherently new. Many conventionally bred crops are by any biological definition transgenic, since they contain genes or segments of chromosomes from totally different crop species. Many of the biological phenomena which are often cited as unique biosafety issues for genetically modified crops actually also occur in conventional plant breeding or other biological processes involving non-modified organisms and in wild species.

27. In the context of biotechnology risk assessment, there is a widely held scientific consensus that risk is primarily a function of the characteristics of a product — whether it is a purified chemical or a living organism to be field tested — and is not per se a function of the method of genetic modification. However, the current legal definitions of genetically modified organisms upon which most biosafety legislation is being constructed are largely process- rather than product-oriented. The scientific consensus emerging from the vast range of biosafety studies of transgenic plants is that each case should be evaluated on its own merits and hazards. Hence, biosafety decisions might differ according to the particular type of transgene, crop, environment and end use involved.

28. There is no evidence to suggest that transgenic crops or biotechnology per se would either decrease or increase biodiversity in agricultural or in "natural" ecosystems. Within agricultural systems, plant biotechnology research could be applied to either increasing or decreasing genetic diversity, depending on research objectives. With modern biotechnological methods, the use of the genetic resources from wild crop relatives may actually increase. The selective advantage that a particular genetically modified organism will confer in the agro-ecological niche in which it is applied should be considered in risk assessment.

29. In general, any risks of transgenic crops to biodiversity should be assessed relative to other non-transgenic options. Most risk assessment studies regarding genetically modified organisms fail to do comparative studies to assess each particular risk relative to the levels of risk to health and environment from other options.

30. Many naturally occurring plant proteins and compounds can be anti-nutrients, toxic or allergenic. Indeed, a significant number of crop species are toxic if not cooked or prepared properly to reduce or inactivate such compounds. There is currently no scientifically accepted evidence to suggest that transgenic foods per se are any more or less toxic or allergenic for humans than their conventionally bred counterparts. Indeed, genetic engineering approaches and other research approaches are under way to develop "functional foods" or "nutraceuticals" which would contain lower levels of allergens and toxins or higher levels of beneficial compounds than conventional foods.

31. Consumers have a definite right to information and hence choice regarding which foods they purchase or eat. However, consumer information is based on the premise that the information provided to the consumer is of utility to the consumer in making an informed choice. Labelling is increasingly perceived as necessary by both the biotechnology industry and some Governments to meet consumer concerns, and several OECD countries require labelling of transgenic foods. The United States of America requires labelling of transgenic foods that are substantially different from their unmodified counterparts, including foods that could contain a potentially allergenic compound, such as a peanut protein or glutenins.

32. Since this is a new area in which many developing countries lack technical expertise, there is need for technical assistance and capacity-building on biotechnology and on risk assessment of genetically modified organisms to allow for adequate biosafety measures to be implemented by countries.

V. Biotechnology, intellectual property rights, and the private sector

33. The global market for agricultural biotechnology products was less than US$ 500 million in 1996 but is projected to increase significantly. As a result, the past decade has seen a major increase in private-sector investment in agricultural biotechnology. According to FAO, private-sector agricultural research in the OECD countries is now in excess of $7 billion and accounts for half the world's entire agricultural research investment. As a result of recent mergers and acquisitions, there are now fewer small agricultural biotechnology companies. In some countries, antitrust enforcement policies are sometimes required for consumer protection when competition between industries is stifled because particular companies have obtained control of a market.

34. For commercial reasons, richer farmers are likely to be the main target market for most privately funded plant biotechnology research, as reflected in the crop focus of current agricultural biotechnology research, which is heavily biased towards major commercial — often export — crops, such as maize, soybean, canola, cotton, tobacco, tomato, potato, squash and papaya, rather than the food staples of poorer populations, such as millet, sorghum, cassava, sweet potato and plantains. There is a need at both the national and international levels to stimulate research and development for non-export staple crops.

35. Extremely high levels of regulation of the biotechnology sector will actually favour larger companies and act as a barrier to entry for smaller companies. Overregulation of all agricultural biotechnology could widen both the technology and income gaps between richer and poorer farmers (or consumers).

36. Intellectual property rights represent a useful means by which private investment in research and development can be promoted. However, alternative or modified incentive structures (e.g., limitations on exclusive licensing) may be more appropriate for public-sector research institutions (or for publicly funded research). Intellectual property rights related to agricultural biotechnology products and processes are being claimed by both private firms and an increasing number of public institutions and governments. The differences between different types of intellectual property rights and the issues surrounding their application to pro-poor agricultural biotechnology research have recently been reviewed for the Commission on Genetic Resources for Food and Agriculture.[3]

37. The World Trade Organization (WTO) Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement is to be tentatively reviewed by WTO in 2000. The majority of current patents and plant variety protection certificates are predominantly filed by companies from the OECD countries. It is not yet clear what impact the harmonization of intellectual property rights systems will have on the relative roles of foreign and domestic innovation in the agricultural biotechnology sector in developing countries. To a certain extent, that will depend on what models result from any international harmonization of intellectual property rights. One of the concerns that has been expressed in relevant forums is the relationship between obligations under the TRIPS Agreement, the Convention on Biological Diversity and the FAO international undertaking on plant genetic resources. It is widely considered that there is a need to develop a system that protects and ensures traditional knowledge and farming practice.

38. A key consideration for researchers will be intellectual property rights research exemptions, which refer to the use of protected materials for the purpose of certain research and product development or improvement. In the context of food security in developing countries, there may be some scope for obtaining research exemptions on use of proprietary technologies for non-commercial purposes, such as for neglected crops, non-export crops and subsistence farmers.

VI. What future for agricultural biotechnology and sustainable agriculture and rural development?

39. Expenditures on food staples typically absorb half the income of people below the poverty line. Food staples are their main source of nutrients. There is little doubt that if plant biotechnology research were applied to well-defined social or economic objectives, such as improving the food staples of the poor, it could benefit poorer rural and urban groups.

40. There remains the valid concern that the needs of poorer farmers or nations are unlikely to be a factor which favourably steers the research objectives of biotechnology research, which is dependent on private investment. At the governmental level, there are currently no policy instruments which promote the type of biotechnological research that could contribute to food and livelihood security in resource-poor situations, especially in developing countries. Long-term public-sector investment in agricultural research will be essential to address the needs of poorer farmers and consumers, who do not constitute a significant commercial market for private-sector biotechnology research and development. Increased participation by farmers and other key actors in the overall sustainable agriculture and rural development process is of vital concern. It is important to strengthen the communication among public-sector agricultural biotech research, on-farm research and farmer groups to facilitate the realization of sustainable agriculture and rural development.

41. There is a need to adopt a holistic and integrated approach in the application and evaluation of the impacts of agricultural biotechnology. Evaluation of newly engineered crops must consider biodiversity as a value; monitoring bio-indicators can help in reaching decisions about their environmental impacts. Many actions in several fields need to be developed by Governments and by international organizations to make sure that the pro-poor potentialities of agricultural biotechnologies are realized. Care should be taken that the current gap between developing and developed countries does not increase as a result of their lack of appropriate action concerning those key issues.

Notes

[1] See Per Pinstrup-Andersen et al., *World Food Prospects: Critical Issues for the Early Twenty-First Century*, 2020 Vision Food Policy Report (Washington, D.C., International Food Policy Research Institute (IFPRI), 1999); IFPRI, a member of the Consultative Group on International Agricultural Research, has also looked at the issue in G. J. Persley, ed., *Biotechnology for Developing Country Agriculture: Problems and Opportunities*, 2020 Vision Focus 2 (Washington, D.C., IFPRI, 1999).

[2] Under the Cartagena Protocol on Biosafety, Governments will signal whether or not they are willing to accept imports of agricultural commodities that include living modified organisms by communicating their decision to the world community via an Internet-based biosafety clearing house. In addition, shipments of commodities that may contain living modified organisms are to be clearly labelled. Stricter advanced informed agreement procedures will apply to seeds, live fish and other living modified organisms that are to be intentionally introduced into the environment. In such cases, the exporter must provide detailed information to each importing country in advance of the first shipment, and the importer must then authorize the shipment. The aim is to ensure that recipient countries have both the opportunity and the capacity to assess risks involving the products of modern biotechnology.

[3] For background information papers on the Committee, visit: http://www.fao.org/ag/cgrfa/docs.htm.